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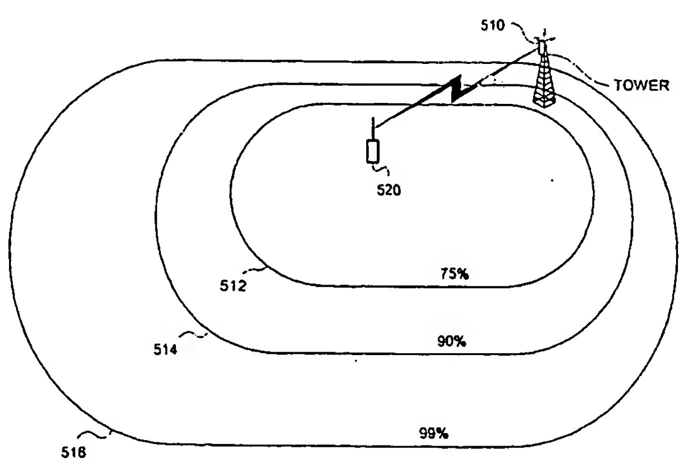
(54) Title: SYSTEM AND METHOD FOR PROVIDING LOCATION INFORMATION CONCERNING WIRELESS HANDSETS VIA THE INTERNET



(57) Abstract: Wireless network signal strength drive test data is translated into Geographic Mark-up Language (GML) shape information indicative of probable location of a handset served by the wireless network. Based on empirical drive test data, geographic shape data is generated for each of the plural sectors of the wireless network. In the event that one or more sector parameters are changed according to a network performance modeling algorithm, the generated geographic shape data for each of the plural sectors of the wireless network is modified. The Home Location Register (HLR) of the wireless network provides a sector ID corresponding to an identified sector of the wireless network serving a particular wireless handset. When a request including a sector ID corresponding to the identified sector serving the wireless handset is received, the geographic shape data for the identified sector is transformed into probabilistic shape information indicative of the probable location of the wireless. The probabilistic shape information is transmitted in response to the received request.

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SYSTEM AND METHOD FOR PROVIDING LOCATION INFORMATION CONCERNING WIRELESS HANDSETS VIA THE INTERNET

CROSS-REFERENCE TO RELATED APPLICATION

INTRODUCTION

[0001] The present invention relates generally to the field of wireless telephony. More particularly, the present invention relates to translation of wireless network signal strength data into shape information indicative of probable location of a handset served by the wireless network.

BACKGROUND OF THE INVENTION

[0002] Over the last twenty years mobile telephones have gone from a mere novelty to a fact of life. The analog cellular telephones that were once toys for the rich and tools for high-powered salesmen are now digital personal communication system telephones that are tools-of-convenience for many families and even popular accessories for school children.

[0003] The mobile nature of all these new wireless telephones throws into doubt the location from which a telephone call is originating. For both public safety and commercial reasons, it is often useful to know this location information. However cellular telephone systems as originally implemented provided little if any information on location of a given wireless handset. The Federal Communications Commission (FCC) has promulgated regulations requiring wireless service providers to develop location determining infrastructures for the handsets using their systems. These regulations require enhanced location resolution in the years to come. To meet these public safety, commercial, and regulatory needs, various location technologies have been developed, or at least proposed.

[0004] The simplest wireless location technology known is the switch-based location method. This method is widely available to wireless operators; every wireless operator

has it at this time. Although it is universally available, it is not very effective because it has a rather poor resolution. Switch-based location simply determines which particular mobile switching center a given handset is being serviced by. Since each mobile switching center usually services a large geographic area, this does not narrow down the location of a given handset very much. For example, a small city may be serviced by a single mobile switching center or may even share a mobile switching center with another nearby small city. More populous metropolitan areas may be served by three to half a dozen mobile switching centers, however this does not narrow down the location very much. Thus, switch-based location provides only crude resolution on the order of which city the handset is in.

[0006] Another location technology that has been developed is sector-based location. Sector-based locations narrow down the location of a given handset to which particular sector of a particular cell site is servicing the handset. This provides a resolution of about one to three square miles. Although not universally available to all wireless service providers, a significant number of the wireless service providers in United States do have this technology in many of the areas they service.

[0007] It has been proposed to enhance the location ability of wireless systems by using external Positioned Determining Equipment (PDE) to better determine position of the given handset based on the signals that are available in a wireless network. Specifically, the external PDE would be coupled to the wireless providers network management equipment to analyze data indicative of angle of arrival (AOA) or time difference of arrival (TDOA) for a particular handset with respect to its nearest sectors (the sector it is being serviced by, as well as adjacent sectors). It is believed that this technology will provide a resolution of approximately 100 meters. External PDE technology is not available to any wireless service providers at this time on anything other than an experimental basis, and the technology remains in a developmental stage.

[0008] It has also been proposed to provide location information using handset-based geographical positioning system (GPS) technology. This technology entails the addition of GPS receiver circuitry into each handset being serviced by the wireless network. Each handset received GPS information from GPS satellites and either conducts GPS location calculations within the handset, or transmits the received GPS data to a central facility on

the wireless network for performing such calculations. This technology promises a resolution of location of the handset of less than 50 meters. Currently, this technology is not available for use by any wireless service providers.

[0009] Thus, we see that the technologies that are readily available to wireless network companies have only crude resolution. The technologies that promise improved resolution are not yet available and will have substantial disadvantages even once they are made commercially available. The external PDE technology will require the wireless network host to purchase additional expensive equipment to perform the AOA and TDOA calculations for the handsets to be located. The handset-based GPS technology would actually require that all the handsets serviced by the wireless network be swapped out for new handsets containing the new GPS receiver circuitry. This, for obvious reasons, presents a substantial inherent barrier to adoption of such a system even if it were technically feasible.

[0010] An additional disadvantage of all the prior art systems is that none of them provides location information in a format that is at all useful for commercial purposes. The crude resolution systems do not provide location information to commercial entities, much less putting such information in a form that could even be potentially useful. The more advanced, higher resolution, technologies such as external PDE and handset-based GPS have the obvious disadvantages that they are unavailable at this time and will not likely become available in any widespread form any time soon.

[0011] Thus, a system would be very useful that provides wireless handset location information in a format that would be useful to commercial entities.

SUMMARY OF THE INVENTION

[0012] It is an object of the present invention to provide location information concerning wireless telephones in a form that is commercially useful.

[0013] It is another object of the present invention to develop shape information concerning sector in a wireless network and converting that shape information into a geographic descriptive language.

[0014] Wireless network signal strength drive test data is translated into Geographic Markup Language (GML) shape information indicative of probable location of a handset

served by the wireless network. Based on empirical drive test data, geographic shape data is generated for each of the plural sectors of the wireless network. In the event that one or more sector parameters are changed according to a network performance modeling algorithm, the generated geographic shape data for each of the plural sectors of the wireless network is modified. The Home Location Register (HLR) of the wireless network provides a sector ID corresponding to an identified sector of the wireless network serving a particular wireless handset. When a request including a sector ID corresponding to the identified sector serving the wireless handset is received, the geographic shape data for the identified sector is transformed into probabilistic shape information indicative of the probable location of the wireless. The probabilistic shape information is transmitted in response to the received request.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Additional objects and advantages of the present invention will be apparent in the following detailed description read in conjunction with the accompanying drawing figures.

[0016] Fig. 1 illustrates a conceptual view of signal flow of location data and point-of-interest information between a wireless network and entities communicating the Internet.

[0017] Fig. 2 illustrates a block diagram view of system architecture and signal flow according to a first embodiment of the present invention.

[0018] Fig. 3 illustrates a block diagram view of system architecture and signal flow according to a second embodiment of the present invention.

[0019] Fig. 4 illustrates a flow chart of an algorithm for practicing the method according to the present invention.

[0020] Fig. 5 illustrates elimination of adjacent edges to form a single polygon according to an algorithm aspect of the present invention.

[0021] Fig. 6 illustrates a polygon that has been formed with enclosed spaces according to an algorithm aspect of the present invention.

[0022] Fig. 7 illustrates elimination of enclosed spaces by forming two polygons according to an algorithm aspect of the present invention.

[0023] Fig. 8 illustrates a conceptual view of a set of probability contours associated with a particular sector of a wireless network.

DETAILED DESCRIPTION OF THE VARIOUS EMBODIMENTS

[0024] Referring to **Fig. 1**, the general flow of location data and point-of-interest information is illustrated conceptually. Location data concerning a wireless device **10** is generated within the wireless network **20** based on which sector of the wireless network **20** is servicing the wireless device **10** via sector handshaking. The wireless network **20** provides location data both to commercial entities via a global interconnected network of networks **40** (for example, the Internet) and to a Public Safety Access Point (PSAP) **30**. The trading of location data for point-of-interest information may be conducted according to a sub describer-initiated mode of operation, or according to a merchant-initiated mode of operation.

[0025] Subscriber-initiated commerce is conducted wherein the user of the wireless device **10** deliberately seeks out information and causes location data concerning the wireless device **10** to be provided to commercial entities, such as a merchant **60** or a service provider **50**. Based on the location data received from the wireless network **20**, the merchant **60** or the service provider **50** responds by sending point-of-interest information back through the network **40** and the wireless network **20** to the wireless device **10**. This mode of operation is useful in the event the user of the wireless device **10** would like to know the location of the nearest automatic teller machine, or the nearest Mexican restaurant, the nearest Staples store, or any other location-based information. All of these inquiries may be satisfactorily answered by providing location data to the relevant service provider **50** or merchant **60** who may then respond with an answer to the geographic proximity question with point-of-interest information.

[0026] Merchant-initiated commerce, on the other hand, relies upon a regular stream of location data being provided from the wireless network **20** to the commercial entities via the network **40**. It is useful for the service provider **50** or the merchant **60** to receive location data indicating when the wireless device **10** is physically proximate to their respective places of business. For example, if the wireless device is in the vicinity of the merchant **60**, location data indicating this will give the merchant **60** a timely opportunity to transmit an advertisement, or an electronic coupon as point-of-interest data to the

wireless device **10**. Thus, the user of wireless device **10** becomes a commercial target-of-opportunity for making a sale while they happen to be in the neighborhood.

[0027] Referring to **Fig. 2**, system architecture and operation according to a first embodiment of the present invention are illustrated. A home location register **110** maintains an immediately current index of which sector of the wireless network **20** is servicing the wireless device **10**. An Instant Messaging Presence and Location (IMPL) server **200** is connected so as to receive information from the HLR **110** concerning sector ID information for wireless devices on the wireless network **20**. The IMPL server **200** is connected between the HLR **110** of the wireless network **20** and the network **40** so as to provide a communications link between users of the network **40** and users of the wireless network **20**. Detailed explanation concerning the operation and architecture of an IMPL server **200** for use by the present invention is disclosed in co-pending U.S. Patent application no. 09/771,201, filed January 26, 2001, which is incorporated by reference herein, in its entirety, for all purposes.

[0028] The IMPL server **200** contains a database software module **230** concerning presence, location, and profile information for the various wireless devices on the wireless network **20**. A carrier stack software module **210** provides for orderly updating and use of information into and out of the database **230** with respect to the wireless network **20**. An Internet stack software module **240** provides for orderly accessing of presence location information from the database **230** by commercial entities **130**, **140**, **150** connected to the network **40**.

[0029] A wireless network modeling database **220** is provided at the IMPL server **200** as a software module that models the sector by sector performance of the wireless network **20**. Performance modeling by the database **220** is based primarily on drive test data **222** that is updated on a continuous basis by the operator of the wireless network **20**. The wireless network modeling database **220** has the capability of portraying graphically not only the drive test-based performance information for sectors of the wireless network **20**, but additionally, to predict performance changes based on hypothetical parameter modifications of the wireless network **20**. For example, the performance modeling database **220** is capable of showing modified performance for network sectors based on changes in antenna height, antenna azimuth, antenna type, frequency plan and color code,

antenna location, terrain height, and antenna down tilt. Particularities of architecture and operation of the wireless network-modeling database **220** are disclosed in detail in co-pending U.S. Patent application no. 09/462,201, filed August 21, 2000, which is incorporated by reference herein, in its entirety, for all purposes.

[0030] Whenever new drive test data **222** is provided to database **220**, or when modeling is performed based on parameter changes in the database **220**, the performance of each of the sectors of the wireless network **220** is modeled. Location information to be used according to the present invention is based on this sector performance information in the wireless network modeling database **220**.

[0031] Conceptually, the carrier stack **210**, the wireless network modeling database **220**, the presence, location, and profile database **230**, and the Internet stack **240** may be viewed as separate software modules all running on a common IMPL server **200**. Of course, as would be understood by those of ordinary skill in the art, any of these software modules may be implemented on a separate server in communication with the software modules running on the IMPL server **200**. In fact, the IMPL server **200** may, in the alternative, be configured as a thin client and all of the software processes represented by the illustrated software modules **210**, **220**, **230**, **240** are remotely provided by an application service provider (ASP).

[0032] According to a mode of operation according to the first embodiment of the present invention, sector identification information concerning a particular handset is provided from the HLR **110** to the carrier stack **210** (step **A**). The carrier stack **210** then sends the sector identification information (step **B**) to the wireless network modeling database **220** which then returns to the carrier stack **210** geographic shape data indicative of location. The carrier stack **210** then provides the location data (in the form of geographical shape data) concerning the particular handset to the database **230** (step **C**) for subsequent retrieval by interested parties **130**, **140**, **150** on the network **40**.

[0033] Referring to **Fig. 3**, an architecture and operational flow according a second embodiment of the present invention is illustrated. Sector identification information corresponding to the wireless device **110** is supplied by the HLR **110** to the carrier stack **310** (step **A**). The carrier stack **310** then forwards the sector ID to the presence, location, and profile database **330** (step **B**). According to this mode of operation of the second

embodiment, the sector ID information is warehoused in the database 330 and is converted into location information only on the initiative of some entity exterior to the IMPL server 300. For example, a merchant **140** (or equivalently, a service provider **130** or a portal **150**) initiates further processing by sending a request via the network **40** to the Internet stack **340** of the IMPL server 300 (step **C**). The Internet stack **340** then passes the request on to the presence, location, and profile database 330 (step **D**). Upon receiving the initiating message from the Internet stack **340**, the profile database 330 sends a request, accompanied by the sector ID information to the wireless network database **320** (step **E**).

[0034] Upon receiving the request accompanied by a sector ID, the modeling database **320** calculates location information (in the form of geographic shape data) and returns that information to the profile database 330 (step **E**). The profile database **330** then returns to the initiating merchant **140** the requested location information via the network 40.

[0035] As an alternative mode of operation, the generation of location information may be initiated by the user of the wireless device **10** and then sent to a commercial entity of its choice selected from, for example, a service provider 130, a merchant **140** or a portal **150**.

[0036] Referring to **Fig. 4**, a flow chart for an operational algorithm of a wireless network modeling database according to the present invention is illustrated. In the event that new drive test data is received at the modeling database 410, the new drive test data is loaded **420** and geographic shape data is updated for all sectors of the wireless network 430. Additionally, in the event that one or more sector parameters are changed **440**, geographic shape data for each of the sectors is further updated **450**.

[0037] If a location request has been received at the modeling database **460**, then shape data concerning the sector ID corresponding to the location of the wireless device in question is returned to the requester 470. Otherwise, the algorithm continues to await new drive test data or new sector parameter changes or any further location requests being received.

[0038] One aspect of the present invention is the creation of location data in the form of geographic shape information based on a sector ID value. This is a two-step process. The first step is the deriving of one or more shapes that represent location probability for a handset that is being serviced by a given sector of the wireless network based on drive test

data for that sector. The second step is translation of this shape information (the one or more shapes) into shape data that is understandable according to a geographic descriptive language. A geographic language useful for practicing the present invention is, for example, the Geographic Markup Language (GML), or alternatively, a vector description of the contours of the shape.

[0039] A shape algorithm is used to turn empirical data into shapes. The input to the algorithm is a series of RF measurements. Each RF measurement contains at least three pieces of information:

1. received signal strength (in dBm)
2. a cell/sector identifier
3. a location (latitude, longitude, in degrees)

RF measurement equipment provides the first and third pieces of information. The second piece of information may be conveniently provided by network performance modeling software that uses an algorithm to determine the most likely sector to have transmitted the signal that was measured.

[0040] The output of the shape algorithm is a polygon associated with each Sector in the wireless network. The polygon represents a contour within which a mobile device is likely to be located. It is not required that there be only a single contour for each cell/sector, because the sector coverage area could be discontinuous. In the case discontinuous sector coverage, there would naturally be multiple contours for an area in which the mobile device is likely to be located. For example, sectors may map to polygons as follows:

Sector Id	***Contours***
1	Contour #1 description
2	Contour #2 description
	Contour #3 description

[0041] Contours can be output in any geographic modeling language. For example, GML 2.0 defines a *Polygon* and a *LinearRing* object that could be used to describe the polygon. For Sector Ids that have multiple contours (e.g., Sector 2 above), GML 2.0 defines a *MultiPolygon* object. Alternatively, they are encoded as multiple *LinearRings*.

[0042] If the application requires a single point (e.g. latitude and longitude) instead of a polygon, this can easily be produced as a by-product of the polygon algorithm. To reduce the polygon(s) to a single point requires the straightforward calculation of the geographic average (centroid) of the above polygons:

Sector Id	*Centroid*
1	Contour #1 centroid
2	Contour #2, Contour #3 centroid

[0043] Determination of the polygon is performed using empirical data that is provided (as indicated above) as a series of measurements at different coordinates. The following steps are used to build a polygon:

- The data is averaged geographically using an appropriate average bin size. This removes localized variations and normalizes the data.
- The resulting bins are actually squares (a special polygon, but still a polygon). Each square has a signal strength and Sector Id associated with it. The binning algorithm is designed in such a way that adjacent bins/polygons share sides.
- In order to create a polygon, the algorithm iterates through each bin, checking whether it contains any adjacent sides to other bins with the same Sector Id.
- As adjacent sides are discovered, they are deleted, and the points that used to form separate polygons are merged into a single polygon. This is shown in **Fig. 5**.
- Output GML text identifying the final polygon(s).

[0044] Depending on actual bin location, it is possible for this algorithm to produce "enclosed" spaces, as shown in **Fig. 6**. The enclosed spaces violate the original polygonal properties of the shape. In order to eliminate these enclosed spaces and preserve the polygons, the algorithm is modified to check, each time two shapes are collapsed into one, whether an enclosed space has been created. With this modification, the algorithm produces the distinct polygons **1**, **2** as shown in **Fig. 7**.

[0045] Creation or updating of shape information concerning each of the sectors in the wireless network is done each time new drive test data is input, or whenever modeling is done according to a parameter change for one or more sectors of the network. For each sector, the shape data comprises one or more two-dimensional shape contours that indicate

the probability of where a handset would be located assuming it were being serviced by that sector.

[0046] Referring to **Fig. 8**, a conceptual view of a set of probability contours associated with a particular sector of a wireless network is illustrated. The plural shapes illustrated indicate varying levels of probabilistic confidence in whether a handset **520** is located inside that given contour. For example the smallest shape **512** indicates a 75 % confidence factor that the handset **520** being serviced by the identified sector **510** is located inside the contour of that shape. A second, larger shape **514** would indicate, say, a 90 % confidence factor that the handset **520** being serviced by the identified sector **510** is located inside the contour of that shape. A third, still larger shape **516** indicates the boundaries of a region in which there is a 99 % confidence factor that the handset **520** being serviced by that sector **510** is located.

[0047] The multiple shapes **512, 514, 516** corresponding to diverse confidence factors are useful to meet the needs of different information users. A commercial user may be satisfied with the 75 % probability shape to indicate whether a handset is in the neighborhood of their establishment. On the other hand, public safety usage of the location information may require the best possible (i.e. 99 % confidence factor) certainty as to the location of a handset. When a location information request is received at the wireless network modeling database, the database need not return all of the entire set of shapes of shape information corresponding to that sector. Rather, only the shape corresponding to the confidence factor required by the requestor need be sent.

[0048] To provide the shape information in a useful format, the translation of the shape information into a geographic descriptive language (e.g., GML) is performed. This translation takes the shape data as updated in the modeling database from a graphical format into a GML coding that indicates position in space as well as shape and size. For example a GML coding of a piece of shape information may correspond to a circle having a specified position in space at its center and a particular radius. Also, the information may be in the form of an ellipse when coded in GML, indicating not only the location but the size of the major and minor axes and orientation thereof. GML may also be used to describe regular and irregular polygons as appropriate.

[0049] The present invention has been described in terms of preferred embodiments, however, it will be appreciated that various modifications and improvements may be made to the described embodiments without departing from the scope of the invention.

WHAT IS CLAIMED IS:

1. A method for generating location data concerning a wireless communication device being served by an identified sector of a wireless network, the method comprising:

generating geographic shape data for each of the plural sectors of the wireless network based on empirical drive test data;

modifying the generated geographic shape data for each of the plural sectors of the wireless network, in the event that one or more sector parameters are changed according to a network performance modeling algorithm;

receiving a request for location data concerning the wireless communication device, the request including a sector ID corresponding to the identified sector serving the wireless communication device;

transforming the geographic shape data for the identified sector into probabilistic shape information indicative of the probable location of the wireless communication device; and

transmitting the probabilistic shape information in response to the received request.

2. The method for generating location data of claim 1, wherein generating geographic shape data for each of the plural sectors of the wireless network comprises:

geographically averaging the empirical drive test data to provide bins, each bin having a signal strength and Sector Identifier;

iterating through each bin to check whether it contains any adjacent sides to other bins with the same Sector Identifier;

deleting adjacent sides between bins having the same Sector Identifier to merge the bins into a single polygon associated with that Sector Identifier;

producing text to identify the polygon formed by merging; and

repeating the steps of deleting and producing until one or more polygons have been generated for each of the plural sectors of the wireless network.

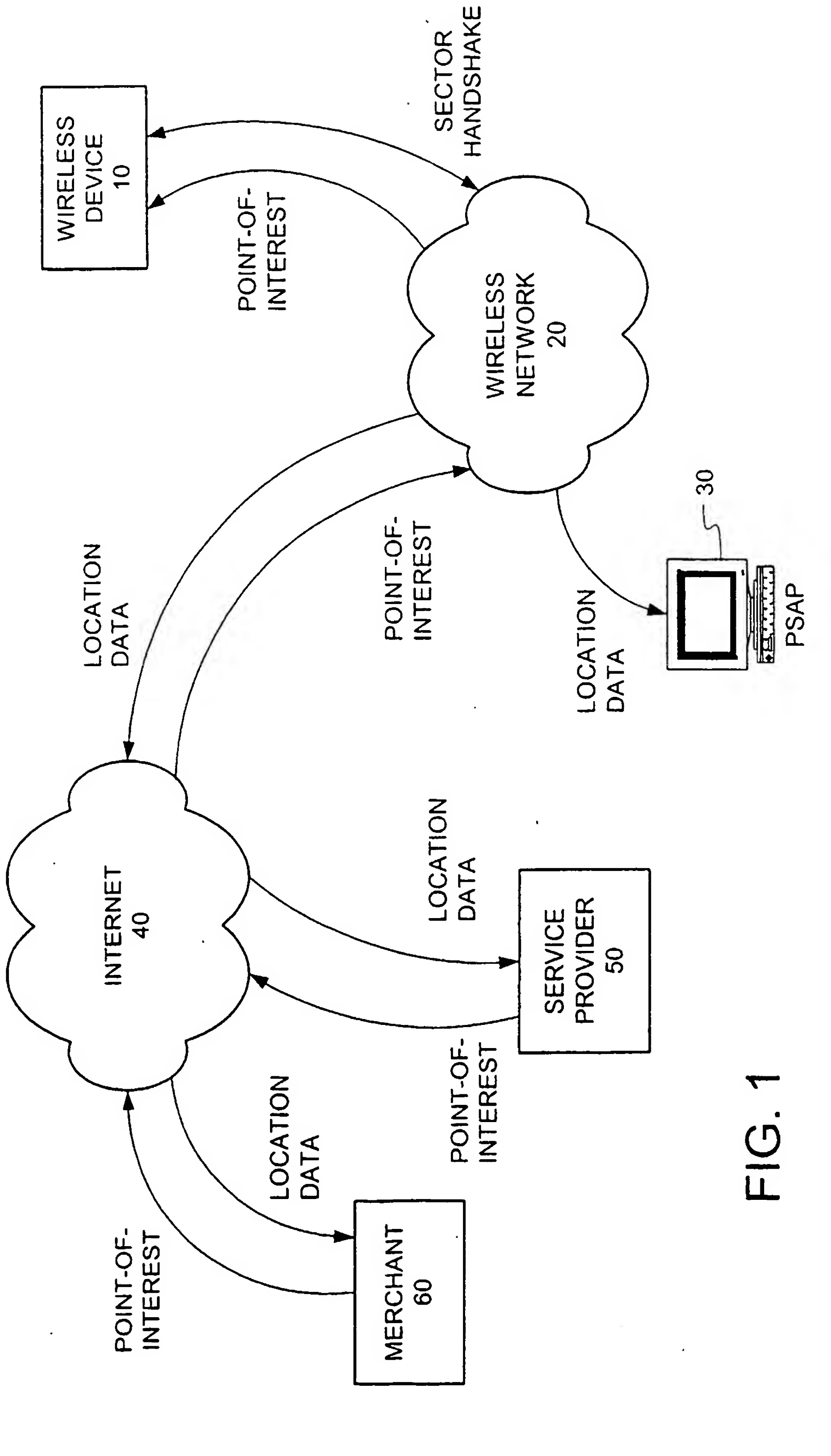
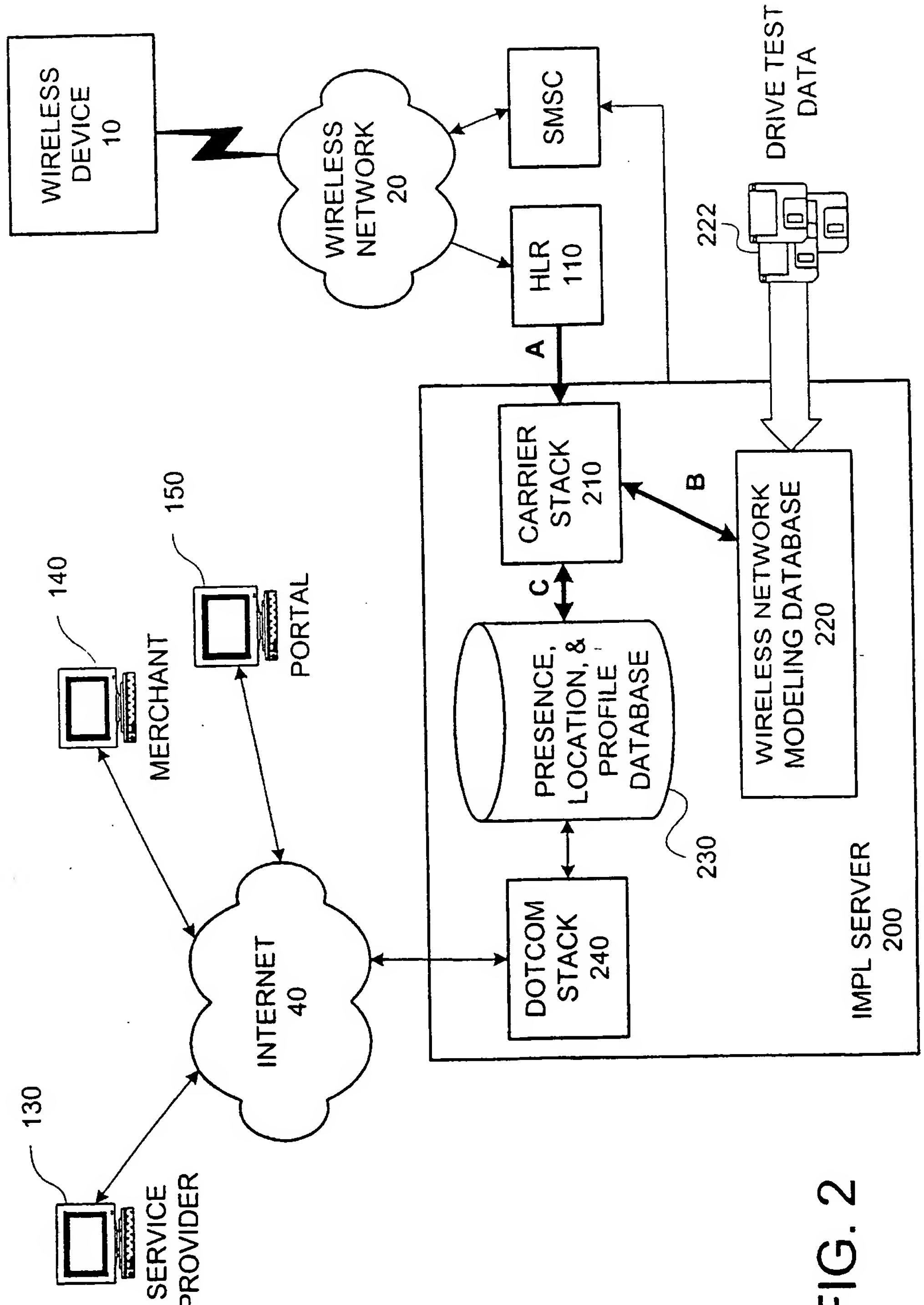

WIRELESS DEVICE 10
SECTOR HANDSHAKE
POINT-OF-INTEREST
WIRELESS NETWORK 20
30
PSAP
LOCATION DATA
POINT-OF-INTEREST
LOCATION DATA
INTERNET 40
LOCATION DATA
SERVICE PROVIDER 50
POINT-OF-INTEREST
LOCATION DATA
MERCHANT 60
POINT-OF-INTEREST

FIG. 1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WIRELESS NETWORK 20
SMSC
HLR 110
DRIVE TEST DATA
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A
CARRIER STACK 210
B
WIRELESS NETWORK MODELING DATABASE 220
C
PRESENCE, LOCATION, & PROFILE DATABASE
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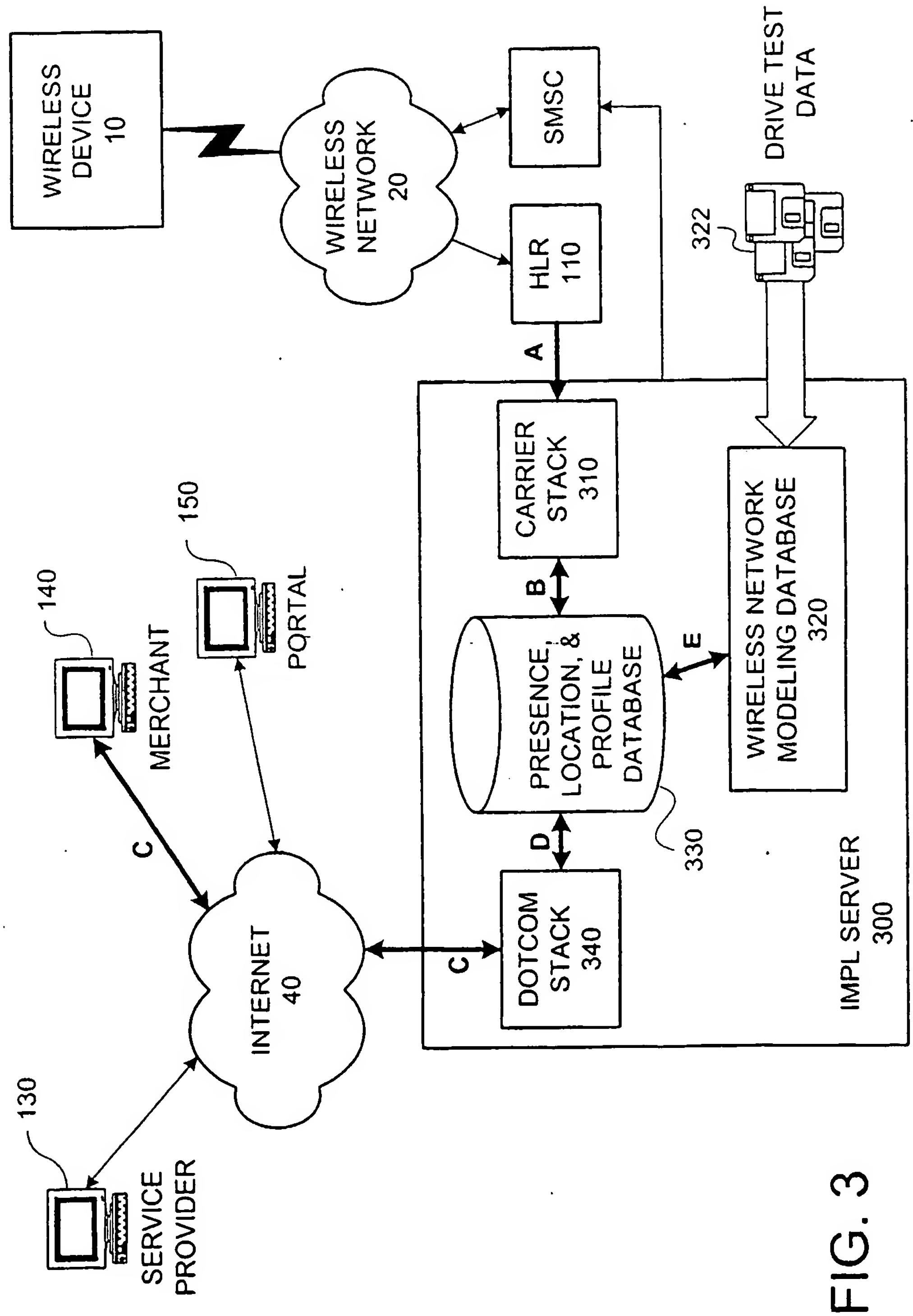
DOTCOM STACK 240
IMPL SERVER 200
INTERNET 40
140
MERCHANT
150
PORTAL
130
SERVICE PROVIDER

FIG. 2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CARRIER STACK 310
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B
E
PRESENCE, LOCATION, & PROFILE DATABASE
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IMPL SERVER 300
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INTERNET 40
C
MERCHANT
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PORTAL
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SERVICE PROVIDER
130

FIG. 3

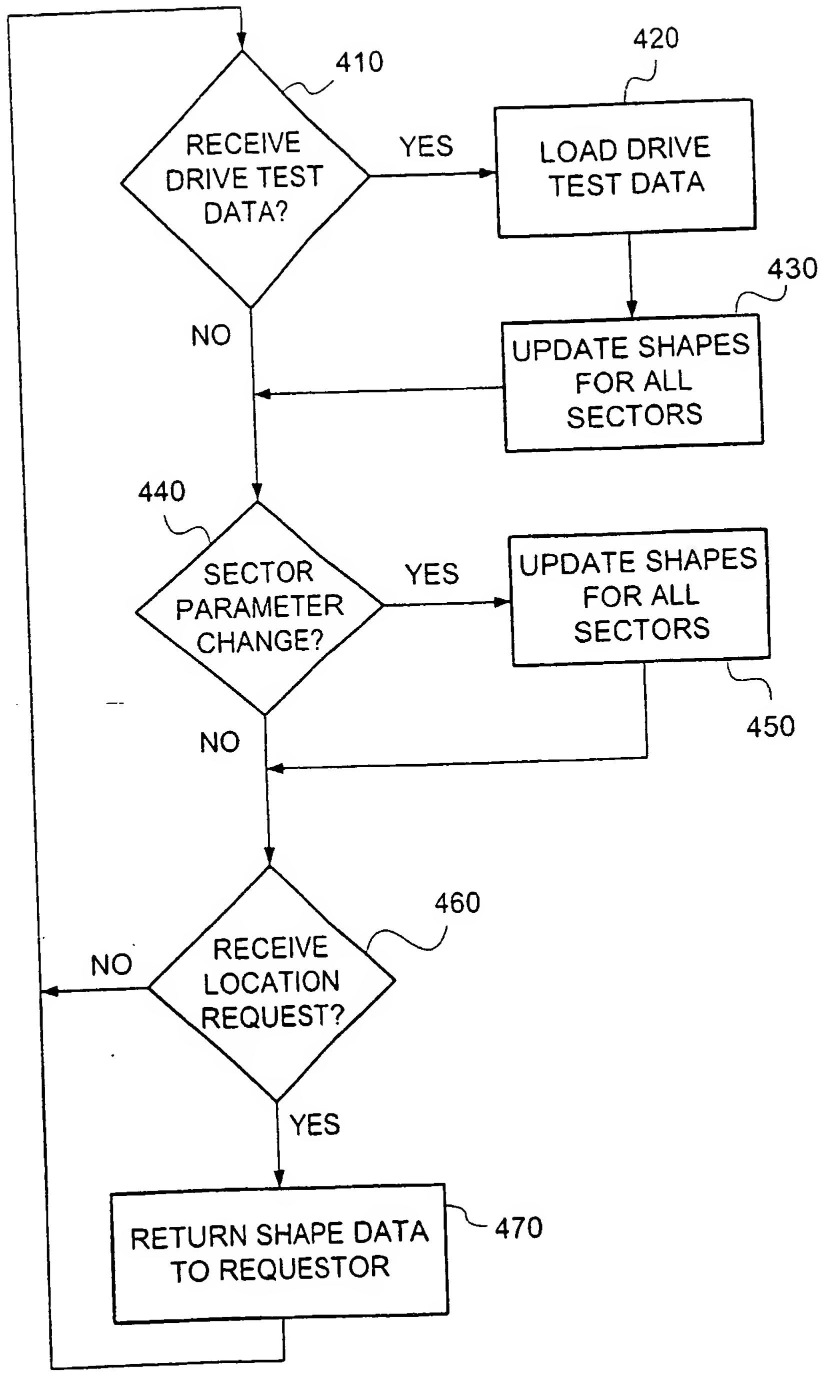

410
RECEIVE DRIVE TEST DATA?
YES
420
LOAD DRIVE TEST DATA
430
UPDATE SHAPES FOR ALL SECTORS
NO
440
SECTOR PARAMETER CHANGE?
YES
UPDATE SHAPES FOR ALL SECTORS
450
NO
460
RECEIVE LOCATION REQUEST?
NO
YES
RETURN SHAPE DATA TO REQUESTOR
470

FIG. 4

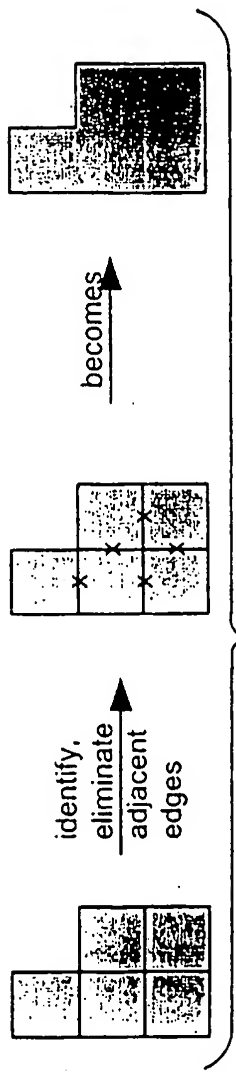


FIG. 5

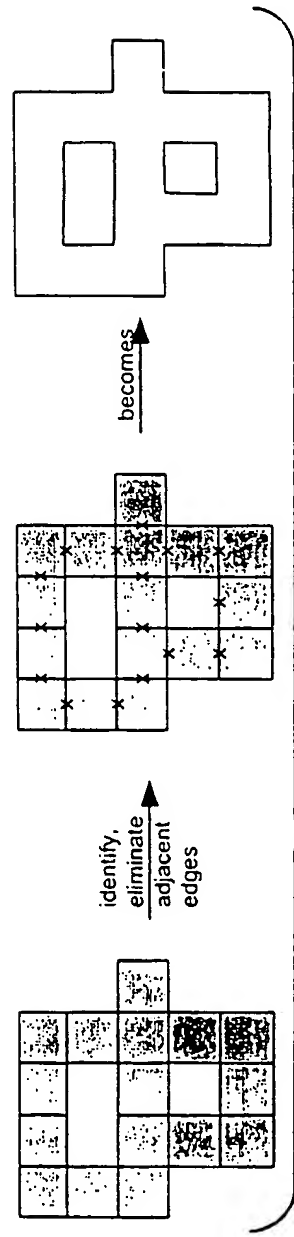


FIG. 6

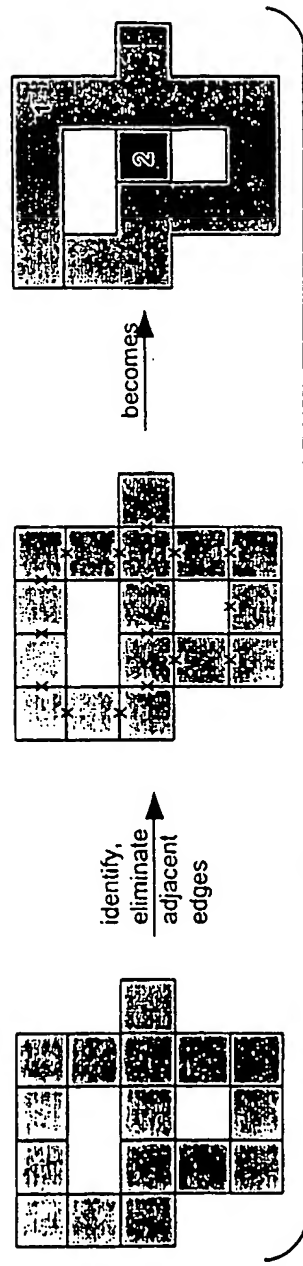
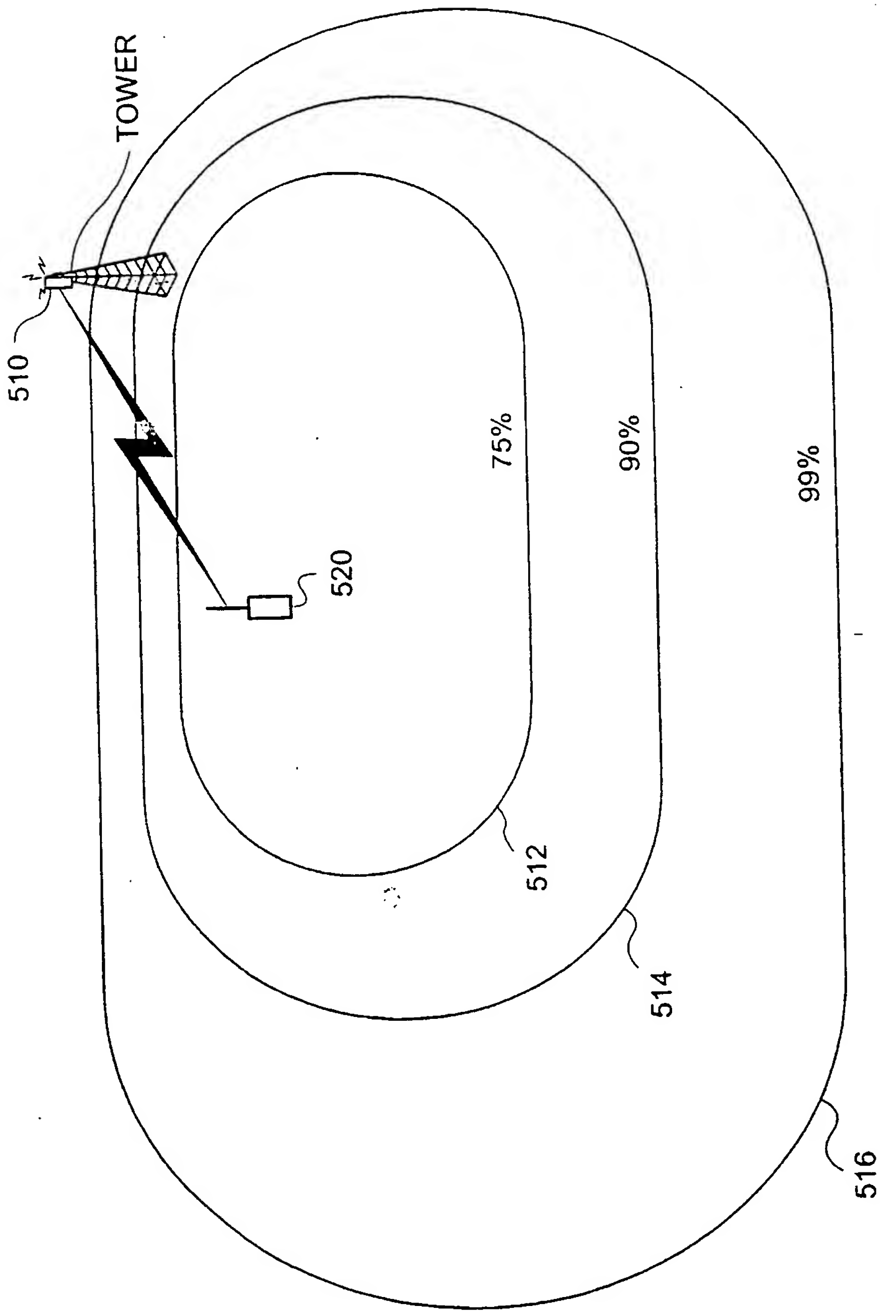


FIG. 7



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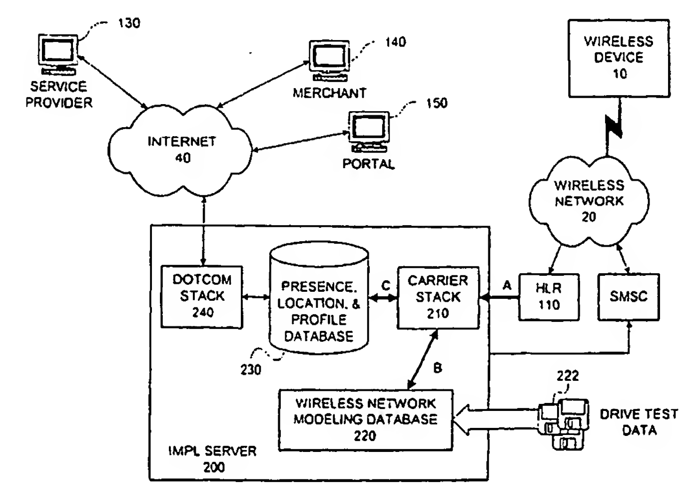
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SYSTEM AND METHOD FOR PROVIDING LOCATION INFORMATION CONCERNING WIRELESS HANDSETS VIA THE INTERNET



(57) Abstract: Wireless network signal strength drive test data (Fig. 2) is translated into Geographic Mark-up Language (GML) shape information indicative of probable location of a handset (10) served by the wireless network (20). Based on empirical data, geographic shape data is generated for each of the plural sectors of the wireless network. The Home Location Register (110) of the wireless network provides a sector ID corresponding to an identified sector of the wireless network serving a particular wireless handset (10). When a request including a sector ID corresponding to the identified sector serving the wireless handset is received, the geographic shape data for the identified sector is transformed into probabilistic shape information indicative of the probable location of the wireless handset. The probabilistic shape information is transmitted in response to the received request.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/04499

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04Q 7/20
US CL : 455/456, 414, 426
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/456, 414, 426, 457, 404, 556, 557

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

BRS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,E	US 6,389,288 B1 (KUWAHARA et al) 14 May 2002, col 3 line 6-col 4 line 58	1,2
A,E	US 6,366,927 B1 (MEEK et al) 02 April 2002, col 6 lines 9-49	1,2
A,P	US 6,339,746 B1 (SUGIYAMA et al) 15 Januray 2002, col 3 line 13-col 4 line 11	1,2
A,P	US 6,222,482 B1 (GUEZIEC) 24 April 2001, col 4 line 41-col 5 line 63	1,2
A	US 5,470,233 A (FRUCHTERMAN) 28 November 1995, col 6 line 44-col 8 line 57	1,2
A	US 5,594,947 A (GRUBE et al)14 January 1997, col 2 lines 6-64	1,2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

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